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Look who's visiting: supporting visitor awareness in the web

HANS-W. GELLERSEN AND ALBRECHT SCHMIDT
Department of Computing, Lancaster University, Bailrigg, Lancaster LA1 4YR, UK.
emails: hwg@comp.lancs.ac.uk; albrecht@comp.lancs.ac.uk

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Individuals, groups and organizations host places in the World Wide Web to attract visitors, but once they have established a web presence they usually maintain little or no awareness of visiting activity. However, the standard web infrastructure supports the capture of detailed activity-related information. In the first part of this paper, we contribute a preliminary study conducted with expert web hosts in different domains, investigating the use of information on visiting activity as feedback for web operation. From this study, we infer general requirements for web awareness support, based on which we have designed two systems aimed to promote more awareness of web activity and visitors. The first is a system supporting ambient notification of web events, end-user configurability, and ambient display for overview and comparison of activity in a web place. The second system moves beyond awareness of web activity to provide glances into the visitors' sites, introducing reciprocity to the host–visitor relationship. Both systems have been prototyped and deployed in work environments for an evaluation in everyday use.

KEYWORDS: web-based interaction; visitor awareness; web awareness; augmented reality; ambient media; human–computer interaction.

1. Introduction

The World Wide Web was conceived as a global information system, however, it can also be regarded as activity space facilitating social interaction. In this activity space, individuals, groups and organizations stake out areas as places in which they host information for others. As *hosts*, they usually have an active interest in attracting *visitors* to their places, as demand for one's information is the primary success criterion for a presence in the web. Hence, it is straight-forward to assume that hosts should want to maintain an awareness of visiting activity in their places. Yet, usually such activity is only monitored by webmasters rather than the actual information hosts. In this paper, we investigate the utility of web activity information as feedback for hosts, and present two awareness support systems designed to make this utility more effortlessly accessible.

Technically speaking, the World Wide Web is a distributed service and document repository that people use to create and access information. However, when people or

organizations create information in the web this is rather perceived as establishing a presence, and as staking out some territory in the web space. Also, when people access information, this is rather perceived as visiting places, for example homes, shops or project sites. Places serve to connect people: on the one hand the hosts maintain places as their territory, and on the other, visitors enter such places as the locus of service provision. In this relationship, it is usually the hosts' primary concern to attract visitors to their places, for instance, to support business objectives, to promote achievements and knowledge or to transport ideas and viewpoints. During the initial design of a web presence, this concern finds its expression in some general considerations of whom to target and how to target them best, independent of how formal or informal the design process may be. In an operational web presence, the concern for attracting visitors is evident for instance in the common reference to web access statistics as a measure for success.

Yet, once hosts have established a place in the web, they usually have no immediate awareness of who is visiting, or even of general activity in their place. This is quite in contrast to comparable situations in the physical world, in which individuals, groups and organizations design places such as home environments, reception areas, showrooms, exhibition booths and so on to attract visitors. In these real places, hosts maintain a high degree of visitor awareness. Depending on the situation, this can span from general awareness of how busy a place is and of how popular specific areas within a place are, to specific awareness of who the visitors are and what they show interest in. In web places this is fundamentally different. Visitors come and go unnoticed, and the fact that a place has visitors is usually reduced to notions of hit rates (a ''hit'' denoting access to a web resource). It has to be noted that this is not imposed by any constraints in the web infrastructure. Standard web server technology has built-in facilities for capturing detailed access information that would lend itself to be mined for the purposes of web and visitor awareness.

The research we discuss in this paper is generally based on the assumption that hosts should want to maintain more awareness of activity and visitors in their web places. A fundamental question is, in which ways and at what level of abstraction can web activity information be useful for hosts. We investigate this by exploring how hosts of different kinds of web places—a conference site, a web-supported lecture and a project web—utilize feedback on web activity if the required information is made available to them in an easily accessible way. This exploration provides interesting insights into the general utility of immediate feedback on web activity. Our focus though is on the identification of requirements for awareness support with respect to both utility and usability for web hosts. Based on these requirements we have designed two awareness support systems, one implementing *ambient feedback on web activity*, and the other providing visitor awareness through *glances into the visitor's sites*. The systems have been deployed and evaluated in everyday use, and found to make useful information on web activity and visitors effortlessly accessible. A particular contribution of the ambient feedback system is that it projects activity in a web place into the host's physical environment, providing situated views that link the host's physical territory with their on-line territory. The glances into the visitors' sites on the other hand contribute an entirely new perspective on the host–visitor relationship by introducing reciprocity: whenever a visitor accesses a host's place, the host gets to have a glance into the visitor's place.

This paper is organized as follows. Section 2 reports our initial analysis of how hosts may be supported through feedback on activity in their web places. This includes a brief technical analysis of activity-related information that can be captured in standard web environments, and based on that an investigation of what sort of information hosts would be interested in. Sections 3 and 4 follow to describe design, implementation and use experience of the two awareness support systems, respectively.

2. Web activity information: feedback for hosts in the web

In our model of hosts, places and visitors we aim to support hosts with awareness of visiting activity in their places. To promote awareness of activity, relevant information has to be provided in suitable ways to the host. This brings up the issue as to what is relevant: what are hosts interested in with respect to visiting activity in their places, and how would feedback on web activity impact the host's operation of a web? These are general questions that need to be investigated in the context of the specific objectives that hosts have in operating different kinds of web places. We have approached this by studying the practice of colleagues in our immediate work environment, in which a wide range of web-based services are hosted. Web hosts in this environment have very advanced knowledge of web technology and are most likely not representative for the average web host. However, in focusing the study on this expert user group, we felt we could learn best as to what is possible with respect to using web activity information as feedback in web hosting.

As a background to our investigation, we will briefly analyse the information upon which awareness support can be based: What activity-related information can be captured in standard web environments? The objective is to leverage information available in the web *as it is*, not requiring any extension to the standard protocols. Hence, we will analyse below the information that is in principle available in any web operation.

2.1. BACKGROUND: WEB ACTIVITY INFORMATION

The standard web infrastructure that underlies the places that hosts maintain in the web in principle provides rich information related to visiting activity. To inform design of web awareness support, it is important to understand what information is available, and how it is available to hosts.

In the web infrastructure, a web place—the locus of activity that we are interested in—is defined as a set of resources in the web. Resources can be HTML documents, images, other media objects or arbitrary applications. These resources are made available on web servers, i.e. programs that manage resources and make them available worldwide through the web protocols. A visit to a web place then relates to a request for a resource in the designated set. A request originates from a client, i.e. a program the visitor uses to specify his request, typically a standard web browser. Web servers routinely log requests for resources, with each request considered a "hit" in the web jargon. These server logs constitute a rich information source on web activity.

Based on web server logs, it can easily be tracked as to which pages are accessed by a visitor, which path is taken through a web place, and how much time is spent on each page (roughly). Usually, it can be found out as to where a visitor is based from their internet address or domain name (provided there is no proxy indirection), and where they have been before (provided there is no referrer indirection). Sometimes even the username is available from Cookies or from explicit authentification (e.g. login). Further visitor information is available on the software used (the client operating system and type of browser), the viewing preferences (e.g. with or without images), and possibly the problems encountered during a visit (e.g. access restrictions and timeouts).

This wealth of activity-related information is captured in log files, however, in a presentation that is not easily accessible to the authors or hosts of a web place. The information is not easy to digest, and very low level to support awareness goals such as overall impressions of activity. However, there is a wide range of analysis tools that process log file information to generate abstractions for a range of purposes (e.g. Hallam-Baker & Behlendorf, 1996). For example, web activity information is commonly compiled into reports that summarize visits over certain periods of time, typically days, weeks and months. Such reports may serve purposes such as business justification and service optimization, however, they are not available in a timely fashion which would be expected to support online awareness. Other abstractions of activity-related information are developed for instance for user profiling, but obviously to capture activity stereotypes rather than activity snapshots as desired for general visitor awareness.

2.2. WHAT ARE HOSTS INTERESTED IN?

It seems straight-forward to assume that hosts of web services should want to have feedback on activity in their on-line territories. In related work, anecdotal evidence has been provided of hosts experiencing awareness support as generally rewarding and motivating, for instance by Liechti, Siefer and Ichikawa (1999). However, to inform the design of awareness support we wanted to obtain a better understanding of what aspects of activity hosts would be interested in, at what level of abstraction they would require awareness information to be presented, and how web awareness might impact their web operation practice and surrounding tasks.

To advance our understanding along these lines, we worked with web hosts in our previous work environment, the Telecooperation Office (TecO) at the University of Karlsruhe, Germany. TecO is a division of the Telematics Institute, active in research, teaching, technology transfer to industry and consultancy to a network of high schools. The web is extensively used in this division for service provision in different contexts such as distribution of course material, support of academic events and project collaboration and promotion. More than 10 web servers are operated to support about 30 distinct sites ranging from smaller short-lived places such as workshop pages to continuously evolving places, for instance a web knowledge base provided to high schools in a long-term program. Responsibility for the various web places in the unit involves most of the six full-time research staff and some of the 20 part-time staff as web hosts. All web hosts in this environment have a very advanced understanding of web technologies, and unrestricted access to web server data enabling them in principle to

monitor activity at a very detailed level. With this background, our sample of web hosts cannot be considered representative, however, our interest was in finding out what is possible (rather than what is common) in terms of using activity information as feedback for operation of web places.

For our investigation, we focused on three types of web places: conference or workshop pages, web-based course material and project web spaces. In each of these domains, two or more separate places had been in operation during our study. Our approach was to study our own practice and discuss with the other web hosts as to what their overall objectives in operation of the web places were, how this mapped to specific interest in ongoing web activity, to what extent they obtained feedback, and how this feedback helped or influenced their work.

2.2.1. Experience with conference and workshop places. In the group we studied, several researchers have been involved in recent academic events such as workshop and conference organizers, for example in CSCW'98 and CHI 2000 workshops and in the Handheld and Ubiquitous Computing Symposium HUC'99. For each of these events, a web place was set up with the objective to support solicitation of contributions, review of submissions and overall promotion in the research community. In the case of the conference, the web place also served to support registration.

The web hosts developed quite specific interest in activity in their places, beyond a general goal of achieving good hit rates. In the early stage of promoting their events, they consulted server log statistics specifically to monitor the effect of promotional activities such as call dissemination via email. The web hosts used this information for instance to react to decreasing interest by placement of follow-up calls. Further, they tended to browse log entries to get an impression of who in the community was showing interest by visiting the pages. This was primarily for curiosity, however, one of the hosts used feedback on web activity that was more goal-directed to update his mailing lists. He had a script running over the logs to collect domain addresses of visitors who had looked up more than just the home page and matched these against the email addresses used for announcement of the site. On this basis, he was able to better target follow-up announcements and reminders of important dates.

Closer to the submission deadlines, the hosts tended to scan log entries to get an impression of where to expect contributions from, for instance with repeated access to submission details serving as indication. Occasionally, this information was used to search in the visitor's domain for related work out of curiosity about what they might contribute. Not surprisingly, a dominating interest of the hosts was to keep up with actual submission activity, and all of them used email notification to this end. Following submission, the hosts used their sites to support the review process which was based on assignment of papers to reviewers by URL which allowed the hosts to monitor whether reviewers were picking up their papers. The hosts used this information to selectively send out reminders, and to proactively reassign papers in cases where reviewers were remaining inactive. In this stage, the hosts were also careful to scan logs for failed transactions to react to the possible loss of completed reviews and to avoid reviewer frustration. Finally, in the case of the conference web site the hosts were further interested in registration activity. Again, they used email notification for awareness, feeling an important sense of reward with each registration.

2.2.2. Course material on the web. In a different application domain, the group is using the web to publish slides, recommended reading material and links of interest in conjunction with courses taught at the University. In these cases, the web places are targeted at the students on the course and used for weekly dissemination of material for the next class. Obviously, the course lecturers hosting the respective places are interested in feedback on how the students used the service. The lecturers have an interest to maintain a general awareness of how motivated students are, which may be inferred from overall access rates but also from how the service is used (e.g. download of only mandatory reading or also of optional background material). Beyond this general kind of feedback, the lecturers were also interested in some detailed information, for example which formats the students tended to prefer for download so as to set priorities.

While the course-related web places were targeted at students, they were nonetheless openly accessible, and occasionally the hosts would look up the logs to see whether the site was also being explored from the outside. One of the hosts noted that coming across visitors from other academic sites (which are easy to identify within Germany due to strict domain naming conventions), would frequently prompt him to look up whether similar courses were offered at the visitor's end. He generally found it beneficial to follow these links to learn about related activities. In a few cases, this had led him to find related course material he had not been aware of before, and to initiate contact to others in the teaching community.

2.2.3. Project places in the web for distributed teams. In our work environment, specific web places have also been set up to support information flow in multi-site projects with partners distributed over a number of European countries. In using the web to communicate documents to partners, it was important for the hosts to maintain an awareness of whether the documents are accessed by the partners. Partly, this was useful for overall coordination, but more importantly it helped "to know whether they know", to have a shared context for informal communication. To obtain this awareness, the hosts tended to check logs more often than usual whenever they had put documents on the project web and notified partners.

In the context of these project places, we found another interesting use of web activity information. One of the hosts reported that he was scanning the log files for referrer information, to find out from where in the web the visitors had followed a link to the project site. Often the links originated from the results of a search engine, but in many cases also from links established elsewhere. He used this information in progress reports to the European Commission as funding agency, to 'prove' successful dissemination of project results.

2.3. REQUIREMENTS FOR AWARENESS SUPPORT

A general observation in the study that we conducted in our work environment was that web hosts considered feedback on activity in their places as extremely valuable. In many cases, the feedback was not crucial but at least rewarding or motivating. However, the feedback often supported surrounding tasks, for example decision-making on promotional activities.

In summary, we found the following general usage patterns for web activity information in the studied environment.

(1) Occasional inspection: to obtain an overall impression of activity, or to browse through details that might be useful.
(2) Event awareness: notification of more relevant events; proactive scanning for expected events.
(3) Processing of activity information: to produce statistics, or as described for adaptation of mailing lists.

Occasional inspection and event awareness by far dominated and are, in contrast to the processing of activity information, background tasks that can be addressed by an awareness support system. To support occasional spontaneous inspection and event awareness, a support system has to meet a number of basic requirements.

(a) Timely presentation of activity without much latency.
(b) Support of different abstractions to support different awareness goals, and to capture aspects of interest while reducing information overload.
(c) Presentation at the periphery, not monopolizing the user's attention but enabling them to attend spontaneously.
(d) Effortless access to activity information (in the studied environment access required understanding of server logs; average web hosts will require easier access).

Based on these requirements, we have designed two awareness support systems. The first one, implementing *ambient feedback on web activity*, uses ambient information displays to present web activity information off the screen in the web host's physical work environment. This system supports different awareness goals from awareness of overall activity to awareness for expected events. In addition, we have built a second system that specifically supports the occasional spontaneous access to details on visiting activity through *glances into the visitor's sites*. The glances system works to the effect of providing a host with a display of their visitor's own place in the web.

3. Ambient feedback on web activity

Awareness is a background task: web hosts will want to pursue other tasks while keeping in touch with activity in their web places. Therefore, awareness information should be presented in a way that does not conflict with foreground tasks but that is nevertheless easily accessible. Studies of awareness support systems such as by Greenberg and Kuzuoka (1999) report problems with desktop-based presentation of iconic indicators and video windows that compete with other applications for screen real estate and user attention, and that easily become obstructed by other application windows. An interesting alternative is to move awareness information off the screen and into the ambient environment. Apart from resolving desktop clutter, ambient user interfaces have the quality of engaging users both at the centre and at the periphery of their attention, cf. Weiser and Brown (1996). This means that ambient interfaces

usually reside at the periphery of attention, but that users can at any time move them into the center by explicitly attending to them.

In this section, we present our work on an awareness support system that provides feedback on web activity through ambient information displays. The system is based on an extensible platform for ambient notification of web activity. Based on this platform, we provide mechanisms for end user configurability enabling web hosts to dynamically link events to ambient display effects. On top of the notification platform we have further implemented displays for awareness beyond event notification, supporting overview and comparison of web activity. Prior to the system description and its evaluation we will briefly provide a background on ambient information displays.

3.1. BACKGROUND: AMBIENT INFORMATION DISPLAYS

A number of projects have recently studied as to how ambient environments can be employed for presentation of information. The European project AROMA for instance explored abstract representations suited for display of information in the background of our attention. From this research, Pedersen and Sokoler (1997*a*, *b*) report prototype designs which included, for example armrests displaying information in changes of temperature, and background animations of clouds drifting by at varying speeds. Another early exploration of ambient information display was conducted by Ishii *et al.* (1998) in the ambientROOM, a small office installation equipped with a range of ambient media. The ambientROOM included for example water ripples projected to the ceiling, active wallpaper with light patches, and natural sounds with modulated density to express information (Wisneski *et al.*, 1998). Both AROMA and ambientROOM have shown that the ambient environment is a display resource that lends itself to presentation of awareness information. The projects are also inspiring with respect to the design of ambient media devices that facilitate peripheral information display. An example is the Water Lamp, whose light shines upward through a pan of water that is actuated by changing information, producing changing light patterns on the ceiling of the ambientROOM. An earlier inspiring example of an ambient medium is Jeremijenko's famous "dangling string", a piece of wire hanging suspended from the ceiling at Xerox PARC to display traffic load on the local computer network in terms of vibration, described in Weiser and Brown (1996). In these examples, the displayed information is highly abstracted. However, other work has shown that ambient media can also be applied to richer information display. Rodenstein (1999) for instance demonstrated an ambient display visualizing forecasted weather conditions as overlay on exterior windows.

Recently, ambient displays have also been studied in the specific context of awareness support systems. For instance, Kuzuoka and Greenberg (1999) have designed a number *of Digital but Physical Surrogates* which are tangible representations indicating activity and availability of remote people. Their peek-a-boo surrogate for example is a figurine that rotates to face away if the represented person becomes unavailable. Further, the idea is that manipulation of the surrogates can facilitate the move from mere awareness to actual communication. In other work, Liechti *et al.* (1999) have used ambient audio in a wearable system for personal web awareness. Their system is like ours based on a generic notification platform on top of the standard web infrastructure. In contrast to

their work, however, we have focused on augmentation of the web hosts' physical work environment with ambient displays rather than personal wearable technologies.

3.2. A PLATFORM FOR AMBIENT NOTIFICATION

Earlier work on ambient media has mostly yielded one-of-a-kind installations. One of our goals was to advance this situation and to work toward general mechanisms for the integration of ambient media with digital information. Figure 1 shows a sketch of the ambient media system that we have developed to this end. The system implements an open architecture for the integration of non-computer artefacts as ambient displays of web-based activity. Based on this platform, we have integrated a number of specific ambient media devices that support web awareness in our everyday work environments.

The ambient media system we built is strictly based on standard web technology. It uses the Common Gateway Interface (CGI) to interface ambient media devices integrated with the local web environment of a host. The ambient media devices are non-computer artefacts that support information display through changes in their state and appearance. Media controller provide access to these devices and are partly implemented as a CGI program dealing with display requests and tracking display state, and partly as microcontroller programs for the actual device control. The overall system architecture is shown in Figure 1. In this architecture, notification of web events is realized as follows: web pages are related to ambient media by embedding a link to the controlling CGI program in the HTML code. The link to the CGI program is embedded using the image tag, for instance as given below.

```
<IMGSRC="http://ambientmedia.teco.uni-karlsruhe.de/cgi-bin/
Light.cgi?increment"width="1"height="1">
```

Web pages that include such embedded links are accessed via the standard HTTP protocol (step 1 in Figure 1). The server replies by delivering the document to the

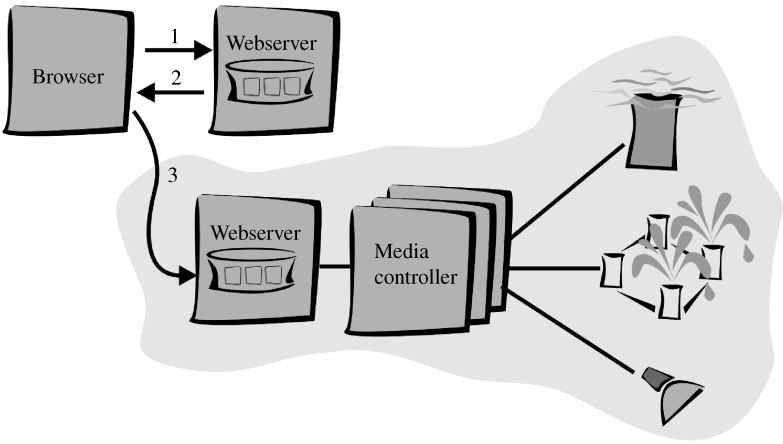

FIGURE 1. The ambient media system is a platform for integration of ambient display devices with the standard web environment.

FIGURE 2. In our office environment, we have integrated non-computer devices such as lamps, a table fountain and a humidifier with the local web environment for ambient display of web-based activity.

browser (2). The browser interprets the HTML code, and automatically triggers HTTP GET requests for the embedded images. By this means, the link to the CGI program is followed (3), and the CGI program gets executed, controlling the ambient display. The CGI program does not return any data to the browser.

For exploration of ambient web awareness, we have integrated three types of devices in our ambient media system, shown in Figure 2: lamps, a table fountain and an ultrasonic humidifier. The lamps used as ambient media are closely associated with the artefacts they illuminate, in particular pictures and posters on our office walls and in the hallway. This is an example of exploiting affordances already available in the environment, and it also illustrates subtle augmentation of "real world" objects. The lamps facilitate ambient display of information by changes in light level, with media controllers for individual lamps as well as for groups of collectively controlled lights. The table fountain and the humidifier are positioned in personal work spaces. The table fountain provides control over four pumps that can be switched on and off independently, supporting variations in ambient display. In our implementation, the fountain media controller is connected to the device via a parallel interface board, and supports seven different display patterns with different degrees of transience (Schmidt, Gellersen & Beigl, 1999). The humidifier in principle supports a continuous change of its state but we use it primarily with a media controller that provides control over three states: off, pulse and overflowing. The pulse and overflowing states lend themselves intuitively for display of bursts and unusually high levels of activity.

The ambient media platform has been designed for flexible extensibility. Additional ambient media can be added by registering a CGI program for their control. The CGI programs provide for abstraction from specific device details.

3.3. CATERING FOR END USER CONFIGURABILITY

In other awareness systems for notification of web or network events, the display effects for certain events are predetermined in the system design. Our analysis of web hosts, however, has shown that their interest in specific events depends on their tasks and

FIGURE 3. An editor for user-controlled creation and deletion of ambient links between events in the web space and display effects in the physical work environment.

priorities that often change over time. For example, hosts often wanted to be more aware of activity that related to recent changes in their web place. In some cases, they wanted temporary awareness of documents they published and expected to be accessed by collaborators. We conclude from these observations that web hosts should be given some control over the configuration of web activity views, to enable them to direct their awareness. To this end, web events and their ambient notification are clearly separated in our approach. We introduce ambient links as a binding mechanism. These links can be anchored in web resources that hosts wish to monitor, to connect them to a specific ambient media device. The anchor is a tag that triggers the execution of a CGI script. As described in the previous section, the image tag can be employed for this purpose.

To ease configuration of the ambient media environment, an ambient link editor is provided, cf. Figure 3. Hosts can use this editor to browse their web territory. On any page they select, they can drop an ambient link, in almost as easy a way as dropping a bookmark in an ordinary browser. From the Ambient Media menu, they can select one of the available devices, and from the Action menu they can choose among the supported display operations. For instance, in the shown screenshot, a conference web page has been selected and linked with the table fountain display, configured to bubble for a brief period every time the conference page is accessed. After selection of web page, ambient medium and display effect, an ambient link is established by pushing the create button, which triggers insertion of the required tag into the selected document.

```
<IMGSRC="http://ambientmedia.teco.uni-karlsruhe.de/cgi-bin/
Fountain.cgi?Bubble5"width="1"height="1">
```

3.4. SUPPORTING AWARENESS BEYOND NOTIFICATION

Ambient links connect web access to ambient display effects and hence primarily promote awareness of singular events, i.e. event notification. Use over longer periods

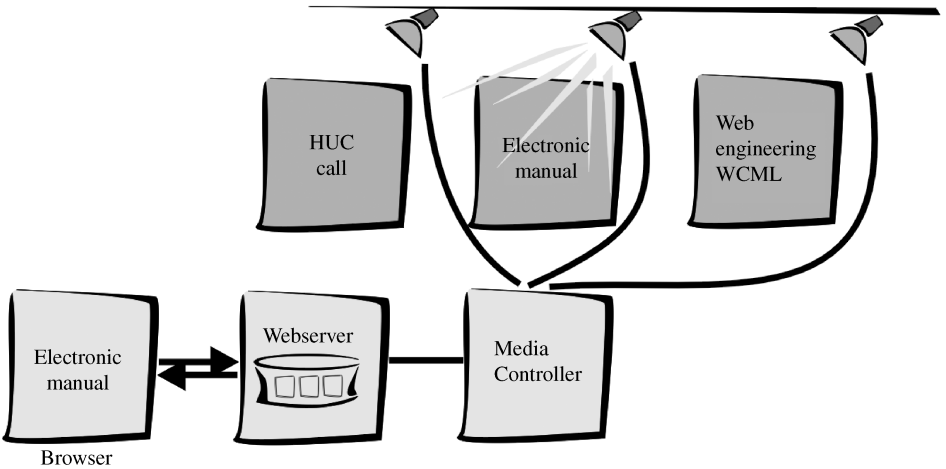

FIGURE 4. The idea sketch for comparative web awareness based on ambient counterparts: posters in our office hallway are illuminated to reflect activity in the related parts of our web site.

may well convey overview information, such as how busy an area in the web is, but the ambient presentation as such does not provide for overview. To address this, we have developed another web activity view, specifically designed to convey overview and comparative information at a glance.

The method is based on the concept of ambient counterparts that we introduced in an earlier publication (Gellersen, Schmidt & Beigl, 1999). Ambient counterparts are based on the observation that entities in web places often have objects in the real world as a counterpart. The idea is to augment such real-world objects as ambient display reflecting activity in the related area of the web. If we have a number of similar areas in a web place, and connect each area to a counterpart, then the aggregation of counterparts constitutes a display that supports comparison. This is illustrated in Figure 4 showing the idea sketch of an ambient display prototype we designed for our work environment. The idea underlying this prototype is to relate project pages in our web site to project posters in our hallway, considering real-world posters as a natural counterpart of the virtual world documents. The posters are augmented with lighting to display activity in the related web space. The lighting is controlled by a CGI program and a micro-controller unit that increases the light level by a fraction whenever a related page is visited, and that slowly decreases the light level over time. With the posters arranged along the hallway, the distribution of light conveys at a glance as to which projects are more popular with visitors than others.

Figure 5 shows an implementation of the display prototype that we installed in our work environment. The two snapshots are extracted from a short video and show two display states with about a minute between them. At first, the display reflects activity in two of the three monitored web places, and later activity in all three web places. It should be noted that the display changes gradually, also capturing more subtle differences as evident from these two snapshots.

FIGURE 5. The two snapshots illustrate display changes in our prototype installation of comparative web awareness. The display first conveys activity in two parts of the web, and later in all three parts.

3.5. EVALUATION

For evaluation of our concepts for ambient feedback on web activity, we have implemented a fully functional system based on the architecture described in Section 3.2. We

have augmented two office spaces with table fountains that blended into the personal work areas facilitating ambient display with both auditory and visual cues. In one of the offices, we also integrated an ultrasonic humidifier that had already been in place. The web hosts in these offices were provided with ambient link editors for control over the ambient displays in their workspace. In addition to the two offices, three posters in the hallway were augmented as described above with light controls for the display of related parts of the work group's web environment. The posters were positioned to be accessible to the whole group, and members of the group would usually walk past the display several times during their workday.

The installations in both office spaces and in the hallway have been subjected to everyday use for over a year. During this time, we collected mostly anecdotal data not only from the web hosts involved, but also from their colleagues who by way of sharing office space came to participate in the augmented work environment. Our interest was to evaluate the system against the requirements inferred from our initial study, and regarding the various uses of web activity information that we had observed in our work with web hosts in different domains. We also conducted a more system-oriented evaluation of architectural properties of our system, but will focus here on the use-related issues.

The concept of ambient linking has been used by individual web hosts in our work group in the context of their personal web pages and of the project sites they were maintaining. For a shorter period in 1999, ambient links were also used by a larger group for awareness of their conference web site. The experience we gathered indicates that user control over ambient media is useful for two kinds of uses: for awareness of anticipated events, and for awareness of web-based processes with slowly shifting focus. For awareness of anticipated events that web hosts did not wish to go unnoticed, they frequently used their ambient link editors for short-term assignment of ambient media. For example, one of the users developed the habit of using his table fountain to monitor access to documents he made available to collaborating partners. His fountain bubbles for a certain period after document access, and depending on his situation he would notice and then check who accessed, would notice but ignore, or would not even notice at all. Obviously, the level of attention paid to the peripheral display depends on the importance and concentration assigned to a foreground task.

Ambient links were also found useful for monitoring processes that involve different web activities at different stages. For example, in the context of a conference web site they were used to assign an ambient display to the page most relevant in a given phase of conference preparation. Specifically, ambient links were first used to monitor access to the call for contributions, then reassigned to tune in on submission activity, then review activity and at last registration. In all these phases, the web hosts did not mind if they failed to notice some activity in a transient peripheral display, however, they always found the display helpful to maintain a sense of how much activity occurred.

Our concepts to support overview and comparison at a glance were evaluated based on experience with hallway poster display. Members of the entire work group walked frequently past the illuminated posters in their workday, which means no explicit effort was required to stay in touch with the web activity information they convey. The information can be taken in literally as people walk by. According to our experience, the poster-based view is very successful in promoting awareness while remaining in the

periphery. All of our group got frequently exposed to the display in their daily routine but reported that they would never walk up to it intentionally to check its state. In contrast, we observed that visitors often stopped in front of the posters, which frequently prompted casual interaction on matters of web access and relative popularity of projects. This was the case both with first time visitors who wondered about the different light levels, and with returning visitors with whom the novelty effect had not worn off as quickly as with the daily users.

Particularly interesting is the motivational effect of the display that we observed in our group. Similar to observations of Liechti *et al.* (1999) with their personal web awareness system, our group experienced feedback on access to their web pages as very motivating. However, in our system motivation was not only drawn from notification that visitors are present but also from viewing as to how popular one's pages were in comparison to the colleague's pages, invoking a friendly sense of competition to keep project pages attractive. This experience suggests that comparative web activity views are useful for groups of web hosts, but we foresee other interesting applications, for example in electronic journalism to provide ambient comparative feedback on the popularity of the various features and columns.

4. Visitor awareness

The awareness support described in the previous section is useful for web hosts in maintaining general awareness of activity in their places but they do not provide them with any information on who is visiting. The specific views that we have introduced with the first system support event awareness and overall impression of activity, but they do not support browsing of any detail. However, our study of web hosts in different domains had shown a range of interesting uses that were based on occasional and spontaneous browsing of web activity details. We have developed a second web awareness system specifically designed to convey more detail on visitors. The basic concept underlying this system is to provide web hosts with glances into their visitors' own places in the web, introducing reciprocity to the host–visitor relationship. The focus of the system is not on awareness of events but rather on awareness of who the visitors are and what they are interested in. In this sense, it relates to work on awareness support conducted in the area of computer-supported collaborative work. We will provide a brief background on this area and then describe design, implementation and evaluation of our prototype system.

4.1. BACKGROUND: AWARENESS SUPPORT SYSTEMS

The computer-supported collaborative work community (CSCW) studies awareness support as a means to initiate communication and collaboration in distributed teams. To this end, awareness information is captured locally and transported to remote team members to be presented in real-time. The awareness information is typically either event-based, for instance arrival of a person as inferred from system login, or video-based. In event-based systems, events are propagated through the network and displayed to potential collaborators in some form of iconic indicator (e.g. Wax, 1996).

In video-based systems, different methods have been introduced, including media spaces, periodic snapshots and video glances. Media spaces provide a continuous video view into a remote place, typically placed in a hallway or social room (Bly, Harrison & Irwin, 1993). Snapshots replace continuous video by low-fidelity images that are updated periodically, for instance, to convey who is around at the other end (Dourish & Bly, 1992). Video glances are brief continuous video connections simulating the kind of brief look into a person's office that people take when they walk past or casually check who is around (Tang, Isaacs & Rua, 1994).

The awareness support methods investigated in CSCW are typically aimed at well-defined groups or communities of people, such as colleagues and "buddies". In the context of the World Wide Web, the study of awareness has been extended to groups of people who are dynamically related via web places. Most of this work has been concerned with supporting awareness among the visitors that happen to be in the same place at the same time, for instance visitors of virtual museum. In this context, awareness support is provided to facilitate social communication and collaborative browsing (e.g. Sidler, Scott & Wolf, 1997). Chat rooms are a straight-forward example of web places set up to facilitate social communication among visitors. In more elaborate systems, audio/video connections are provided to visitors co-located on a site, for instance to augment web-based shopping malls with social exchange among customers (e.g. CoBrow, 2000). In addition to these tool-centric approaches toward web collaboration, there is also increasing interest in design processes for social interaction environments (Jung & Lee, 2000).

While the visitor–visitor relationship has received considerable attention, there is very little work on support of the host–visitor relationship, on which we focus in this paper. An interesting contribution is that of Liechti *et al.* (1999), who introduced a wearable appliance designed to augment web hosts with continuous awareness of their web territory. In this system, web activity is notified with ambient audio and additional awareness information is made accessible through the wrist-worn appliance, which also enables initiation of direct communication with visitors. A distinct design choice is the implementation as a wearable and potentially continuously available tool, in contrast to our approach of creating situated displays of visiting activity as virtual extensions to real-world places. Other work related to visitor awareness for hosts is that of Minar and Donath (1999). They developed a visualization of the dynamics at a web place based on site map in which visitors have an iconic representation. Particular attention is paid to animation of the crowd dynamics whereas our work is geared more toward detail on who the visitors are, or where they are from.

4.2. GLANCES INTO THE VISITORS' SITES

The objective of this awareness support system is to provide access to more detailed information than available in ambient systems but nonetheless in a timely fashion. Our technical approach to achieve this is to use not only local access logs as information source but to conduct a focused web search for additional visitor information. The core idea that we apply is to provide a host with a view of the web site their current visitor comes from. We call this method *glances into visitors' sites* as it applies the same principle to web browsing that video glances apply to video communication. The

glances introduce reciprocity to the host–visitor relationship as hosts get a chance to visit their visitors: you search me—I search you. A glance of a visitor, envisioned as transient display in the background, is primarily aimed to provide the host with a brief view of where the current visitors come from. However, in addition a glance may serve as an entry point to explicit interaction, to browse into the glanced site, or even to invoke direct interaction between host and visitor.

For the glances to be feasible, we have to assume that most visitors to a web site also have a place of their own accessible somewhere in the web. This follows the general spirit of the web as involving users not only as consumers but also as providers of information. This spirit is very much reflected in peer-to-peer communities such as academic research, and special interest groups, but less so in electronic commerce. Obviously, our own design is both inspired by and targeted at use within research communities, but we regard the glances concept to be generally applicable as wider circles of web users become involved as hosts of their own places.

The glances method involves a number of issues that define the system components.

(1) Detect: monitoring server access to detect a visitor to a specific place, and possibly to distinguish whether a visitor is still there or has come back, etc.
(2) Lookup: locating the visitor's place using contextual search heuristics.
(3) Search: collect information of interest at the visitor's end.
(4) Display: provide a view of the visitor's site, possibly interactive.

Detect, lookup and search are all concerned with acquistion of awareness information: this will be discussed in the following subsection. Display of the awareness information, constituting the host's interface to the visitor, will be treated separately in another subsection.

4.3. SEARCHING THE VISITOR

Detection of visitors is a straight-forward task. In principle, monitors can tap directly into web servers (at the cost of server modification), more indirectly into server access logs, or in a distributed fashion into documents of interest (for instance using <img>-tags as described in Section 3). For our glances prototype, we used the second option, continuously checking for new entries appended to the server log.

Lookup of visitors is a more difficult case: access logs give away the Internet address from which a request originates, but this does not directly lead back to a web server. First of all, Internet addresses are based on the IP protocol and do not equal web server addresses which are based on the URL protocol, and secondly a web client from which a request is sent is independent from any web server a visitor may have. For our prototype implementation, we develop the following visitor lookup strategy. First, the IP address is mapped to an Internet domain and a hostname (a hostname cannot always be obtained but in most cases). Then, it is tested as to whether there is a web server on that host trying the most common name scheme "www.<hostname>.<domain>", where "domain" may breakdown into a hierarchy of subdomains. If this fails, the test is repeated one level up by eliminating the hostname part, trying "www.<subdomain>.<domain>". This is repeated until either a server is found or the top-level domain has been reached.

The next task is to collect information of interest at the visitor's end. This is done by a search on the visitor's web server, with interesting design choices for use of search words. One strategy would be to use predefined search words, relating to one's own general area of interest (e.g. "HCI"), or relating to specific types of resources that may be of interest (e.g. "Homepage"). In our implementation, we followed another strategy, applying *reciprocal search*. This is done by using the keywords of locally visited pages for the remote search. For instance, if a visitor is detected on a page with keyword "Interaction design" this term would be used for the search at the visitor's end. The search result would then reflect what the visitor has locally shown interest in. The actual search result can be document addresses (URLs) or specifically extracted information. In our first prototype we simply used the URL of the best matching document.

4.4. INITIAL USER INTERFACE

Our approach to collect information at the visitor's end leaves with a rich resource on which to build awareness displays that convey more detail on visiting activity. We have not begun to fully explore the design space that unfolds but have built early prototypes enabling first use experience. Our main design choices were as follows.

(1) Represent a visitor by a single web page selected at their end based on keyword matching.
(2) Display visitor's pages as partially overlapping window panes, with the latest visitor page on top, and some recent ones still partially visible underneath.
(3) Support transition from awareness to interaction by enabling hosts to surf from a displayed page into the visitor's site.

We implemented the display program in Visual Basic using web-browser components as display panes. This means that each pane in the display is a browser through which the user can follow displayed links and so on. The display program is independent of the reciprocal search technique described above, and basically implemented as a function that takes a URL as input, fetches the respective web page and renders it in a new pane on top of the screen. More precisely, new panes are not generated but instead there is a fixed number of panes of which the lowest is brought to the front and re-rendered. The entire display can be run on any computer screen, however, as it is meant to support a background task we have realized our prototype as a projection in a social meeting room, shown in Figure 6. The first of the two photos shows the display in glance mode with overlaid visitor pages, and the second in browse mode which is entered by clicking into any of pages visible in glance mode. In addition, we have added a few controls to the overall display, to allow hosts to request detailed information and go backward and forward through the sequence of pages that is displayed over time. The rationale is to enable hosts to have easy access to who has been visiting while they were away or did not pay any attention.

4.5. DISCUSSION OF EXPERIENCE

For an initial evaluation of the concept, we have installed glance displays in a shared space as shown in Figure 6 and on dedicated screens in the offices of two web hosts. One

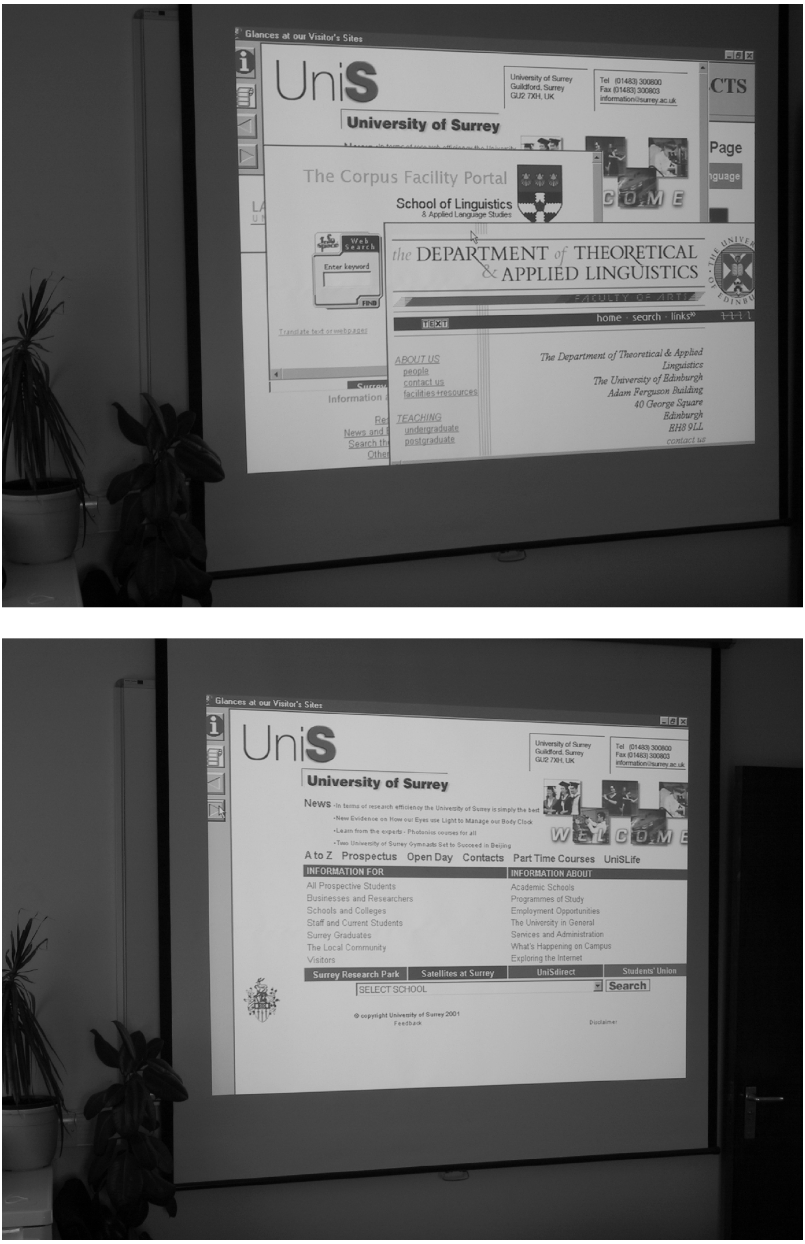

FIGURE 6. Glances into visitor's sites support two display modes. In glance mode (top) recent visitors are represented by a web page from their site, conveying at a glance where they come from. By clicking into one of the displayed pages, users can move from glance mode to browse mode to further explore a visitor's site (bottom).

of the web hosts participating in the evaluation over a period of 2 months used the display for an HCI workshop site and for web-based course material. The other web

host used the display to monitor a web page advertising a new book in linguistics research. A fundamental result across these three application domains was that the visitor search heuristics succeeded for more than 95% of the registered visits. This means that in more than 95% of the cases, the search program was able to find its way back from an Internet address to a web server in the same domain. This is a figure that exceeded our expectations and served to validate the technical approach taken.

In conjunction with the workshop site, the glances display was used by the organizers to obtain feedback on who was showing interests in the published call and in submission. The organizers found that the display provided casually accessible information on which research labs were exploring the workshop site. The workshop organizers were able to associate displayed pages directly with research labs, as they were familiar with labs in their community. However, they suggested that preprocessing of pages might be useful to reduce potential information overload. For example, visitors could be represented by logos extracted from their pages. In general, the organizers found the glances display served primarily for motivation, but in some instances it also guided them to work in their field that they had not been aware of before. Further, they felt that the display was not distracting them from other tasks unless they actively sought distraction.

One of the web hosts who also taught a course on web engineering used the display in conjunction with course material he published on the web. With the use of the glances display he observed, that the web site was not only frequented by his students, but also by academics teaching in the same domain at other Universities. In effect, the display helped him find out who else was teaching in his area, and what relevant resources they had available. The glances display enabled him to obtain this information without any explicit effort. The other web host, who manages a linguistics site, likewise commented that the display made it very easy to stay in touch with who else is active in the field. He also commented that the display readily provided information that he beforehand extracted manually from server logs.

Overall, the experience gathered with our early prototype is clearly preliminary, given the few users we have exposed to it. However, this initial experience indicates that glances into visitor's sites are a useful and effective tool to support awareness within communities. They guide web hosts to visitor's sites based on a notion of common interest. This introduces symmetry to the host–visitor relationship, creating a situation in which both can learn from each other.

However, it is important to understand that glances into visitor's sites challenge the perception of the web as an anonymous information space. Although visitors to web places generally know that they leave digital traces they do not expect to be exposed to the host. Our initial investigation looked at awareness gains for hosts but has not studied the implications for visitors, their perception of the web, and their requirements for protection of privacy. While we have drawn an analogy to video glances there is actually a fundamental difference in that visitors in our scenario will probably not be aware of the return visit by the host. The situation would be different if visitors were explicitly passing their home address to host a site, practically as invitation for a reciprocal search. We have suggested this as simple protocol extension in HTTP, the protocol that clients in the web use to request resources (Schmidt & Gellersen, 2001).

5. Conclusion

In this paper, we have motivated a different view of the World Wide Web as activity space in which hosts have places and receive visitors. With this view as point of departure, we have investigated as to how hosts can be supported with more awareness of activity and visitors in their places. Our main contributions are a study of expert web hosts in three different domains, a platform and concepts for ambient feedback on web activity, and glances into visitor's sites to support the host–visitor relationship.

The presented study is an analysis of what hosts are interested in with respect to visiting activity, and provides insights into how feedback on web activity can be applied by the hosts in different domains. The study helped to identify common usage patterns which include event awareness and occasional inspection. In particular for the latter we identified a range of interesting uses in working with expert web hosts.

The findings from the study informed the design of two awareness support systems. The first one, ambient feedback on web activity, is based on an open platform for the integration of ambient media with the standard web infrastructure. On top of this platform, we have introduced ambient links as a concept to support end user configurability, as well as concepts to support ambient overview and comparison of activity information. The ambient displays implemented and evaluated in this environment support a range of awareness goals including event notification, impression of overall activity, and comparison of activity in different parts of a web space. The ambient displays are realized as augmentation of the physical work environment of the web hosts, providing situated views. In the case of the poster-based activity view, artefacts of the physical environment serve as a display substrate and as affordance for peripheral information display.

The second system that we have introduced, the glances into visitors' sites, approaches web and visitor awareness in a radically new way. In the glances system, awareness is not just based on the local information captured during a visit (pages accessed, time spent, etc.), but in addition on information that is searched for at the visitor's end (i.e. information they have on their pages). On this basis, glances can convey an impression of who is visiting and what their interest is. Moreover, glances may support the transition from awareness to interaction. One can think of the glances display as a portal to the community of visitors that a host has. The concept is powerful in the sense that it introduces symmetry to the host–visitor relationship. This may be considered to be in conflict with the common perception of the web as a medium that people can surf anonymously. However, symmetry enables mutual awareness: visitors learn about hosts they visit, but hosts also learn about their visitors and from their visitors. We believe that this is fundamental for promoting more awareness of common interest among people connected through the web. As our experience with a first simple prototype has shown, the glances concept has the potential to support community building in this sense.

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